# A Quick Reference Guide to

# LCA DATA

# and eco-based materials selection

Cover photo (made by Gijs Korthals Altes):

Designers can make a difference. Windmills of the 18th century in Holland are masterpieces of sustainable design. They were a source of sustainable energy, built from natural materials like wood, bricks, stone and cane. They are beautifully integrated in the Dutch landscape.

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# Preface

Life Cycle Assessment (LCA) is a well-defined method to calculate the environmental burden of a product or service.
The recent book "A practical guide to LCA, for students designers and business managers" (Vogtländer, 2010) is an attempt to explain LCA in such a way that students and other interested people (non-experts) can easily and quickly understand how to do the required calculations.
Another hurdle, however, is to acquire the data required for a specific LCA calculation. Although the internet is the modern source of data, there is still a need for data guides which provide data in an easy and well accessible way. Especially in labs and workshops, it appears that look-up tables in a reference guide are faster than a search on the internet or searches in big computer databases.
A quick reference guide like this one seems to be very useful in the early design phases, when it is essential to have a good overview of alternative design solutions.

This Quick Reference Guide on LCA data provides frequently required data in practice, and gives URLs of where more specific data can be found. The single indicators which are provided in this guide are eco-costs 2007, the Carbon Footprint, CED (Cumulative Energy Demand), and Recipe. The underlying LCA calculations are based on LCIs from Ecoinvent v2.2 and Idemat2010.
The guide also provides charts to select the most appropriate materials for a certain function (Ashby, 2009). The latest educational version of the Cambridge Engineering Selector software, CES EduPack 2011, has been used to make these material selection charts.

My hope is that this book will not only be used by students, but also by designers, architects, and business managers (and their consultants), contributing to the wider awareness that LCA is an indispensible tool in modern design and engineering.

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The Netherlands, December 2010

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# Contents

# 1 LCA indicator tables

On the following pages, so-called 'single indicators' of LCA are provided for materials and products[1]:

- The eco-costs (euro)
- The Carbon Footprint (kg $CO_2$ equivalent)
- The Cumulative Energy Demand, CED (MJ)
- The Recipe indicator (Points)

Eco-costs are 'prevention based' and include toxic emissions and materials depletion. A short description on the eco-costs is provided in Section A.7. A comprehensive description can be found at www.ecocostsvalue.com. The theoretical background is given in (Vogtländer et al., 2010)
The Carbon Footprint in the tables is calculated according to the LCA standards (note that these standards differ from the gate-to-gate Carbon Footprint reporting in business and the simplified Carbon Footprint calculations you can find on the web).
The Cumulative Energy Demand, CED, is a newer (and better) definition of the former 'embodied energy' and Gross Energy Requirement.
Both the Carbon Footprint and the CED are so-called 'single issue' indicators.
The Recipe indicator is the successor of the Ecoindicator 99 (since 2010). Both indicators are 'damage based' and include toxic emissions and materials depletion. Recipe differs considerably from the Ecoindicator 99 (e.g. – 50% to + 100% for metals), and it is considered to be better than the Ecoindicator 99.

Since the Carbon Footprint and CED do not comprise the issue of materials depletion, both indicators perform poorly in C2C calculations.
CED cannot be used in LCA calculations with combustion at the End of Life, since the negative effects of combustion (e.g. emissions caused by combustion of plastics) are not counted.

Most of the Tables are based on the LCIs of Idemat2010. Idemat2010 is based on LCIs of the Ecoinvent v2.2 database. The data on Food (Section 1.12) are based on a combination of Danish data and LCIs of Ecoinvent v2.2.
Data on materials include transport to a harbour in the North Sea region. Data on electricity, transport (rail and road) houses and food are local, as specified in the tables.

The data provided in this Guide are a selection of bigger databases. More data can be found on www.ecocostsvalue.com tab data, excel file 'ecocosts 2007 LCA data on products and services v2-2 2010'. This excel file comprises more than 5000 items.

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[1] Data for other single indicators (e.g. Ecoindicator 99, BEES, and Ecological Scarcity) can be found in a special excel file on www.ecocostsvalue.com tab data.

Data for pure emissions can also be found on www.ecocostsvalue.com tab data, excel file 'ecocosts 2007 LCA data on emissions and materials depletion'. Chapter 2 of this guide provides charts to select the most appropriate materials for a certain function (Ashby, 2009). The latest educational version of the Cambridge Engineering Selector software, CES EduPack 2011 was used to make these materials selection charts.

## 1.1 Metals, production (cradle-to-gate)

*Table 1.1 Metals, ferro, production, cradle-to-gate*

| metals (per kg)<br>Idemat 2010 | eco-costs<br>euro | carbon footprint<br>kg $CO_2$ eq | CED<br>MJ | recipe<br>Pt |
|---|---|---|---|---|
| Crude iron | 0.41 | 1.51 | 23 | 0.17 |
| Steel (21% secondary = market mix average) | 0.49 | 1.61 | 23 | 0.17 |
| Steel (secondary) | 0.12 | 0.42 | 9 | 0.06 |
| cast iron | | | | |
| GG15, GG35 | 0.17 | 0.65 | 11 | 0.07 |
| GGG-NiCr | 1.83 | 1.56 | 27 | 0.32 |
| GGG-NiSiCr | 1.88 | 1.82 | 32 | 0.34 |
| GGG40, GGG60 | 0.17 | 0.65 | 11 | 0.07 |
| GGG70 | 0.21 | 0.72 | 12 | 0.08 |
| GGL-NiCuCr | 1.47 | 1.33 | 23 | 0.26 |
| stainless steel | | | | |
| GX12Cr14 (CA15) | 1.36 | 3.294 | 65 | 0.31 |
| GX5CrNi19 10 (CF8) | 2.50 | 3.991 | 78 | 0.46 |
| X10Cr13 (mart 410) | 1.41 | 3.970 | 79 | 0.37 |
| X10CrNiMoNb | 3.69 | 6.316 | 129 | 0.90 |
| X10CrNiS (303) | 2.36 | 3.872 | 76 | 0.44 |
| X12Cr13 (416) | 1.27 | 3.259 | 64 | 0.30 |
| X12CrNi17 7 (301) | 1.27 | 3.259 | 64 | 0.30 |
| X20Cr13 (420) | 1.40 | 3.365 | 66 | 0.36 |
| X22CrNi17 (431) | 1.60 | 3.502 | 69 | 0.34 |
| X2CrNiMo1712 (316L) | 2.80 | 4.063 | 80 | 0.71 |
| X30Cr13 (~420) | 1.27 | 3.258 | 64 | 0.30 |
| X35CrMo17 | 1.55 | 3.465 | 69 | 0.39 |
| X5CrNi18 (304) | 2.50 | 3.988 | 78 | 0.46 |
| X5CrNiMo18 (316) | 2.87 | 4.098 | 81 | 0.68 |
| X6Cr17 (430) | 1.43 | 3.429 | 68 | 0.31 |
| X6CrNi18 (~304) | 2.50 | 3.968 | 78 | 0.46 |
| X7CrAl13 (405) | 1.28 | 3.266 | 64 | 0.30 |
| X90CrCoMoV17 | 1.55 | 3.546 | 70 | 0.36 |
| X90CrMoV18 (440B) | 1.87 | 4.599 | 93 | 0.43 |
| steel, machining qualities | | | | |
| 10SPb20 (1.0721) | 0.50 | 1.64 | 24 | 0.17 |
| 35S20 (1.0726) | 0.50 | 1.65 | 24 | 0.17 |
| 9S20 | 0.54 | 1.64 | 24 | 0.18 |
| 9SMnPb (1.0718) | 0.50 | 1.62 | 24 | 0.17 |
| steel, cast | | | | |
| GS-10Ni6 | 0.74 | 1.71 | 25 | 0.21 |
| GS-22Mo4 | 0.60 | 1.78 | 27 | 0.21 |
| GS-25CrMo4 | 1.51 | 2.17 | 34 | 0.35 |

| | | | | |
|---|---|---|---|---|
| GS-45.3 | 0.51 | 1.68 | 25 | 0.18 |
| GS-70 | 0.47 | 1.54 | 23 | 0.16 |
| GS-X40CrNiSi 25 12 | 6.18 | 8.70 | 176 | 1.10 |
| HA | 2.06 | 3.94 | 75 | 0.53 |
| HT | 8.15 | 7.69 | 147 | 1.39 |
| steel, construction | | | | |
| Fe360, Fe470, Fe520, St13 | 0.48 | 1.56 | 23 | 0.16 |
| steel, draw | | | | |
| A517a | 0.65 | 1.84 | 29 | 0.23 |
| A517b | 0.63 | 1.81 | 28 | 0.22 |
| S355J2G1W | 0.48 | 1.56 | 23 | 0.16 |
| St14 | 0.48 | 1.56 | 23 | 0.16 |
| steel, high grade | | | | |
| 14NiCr14 | 1.26 | 2.24 | 36 | 0.29 |
| 15Cr3 | 0.60 | 1.80 | 28 | 0.19 |
| 18NiCr8 | 1.10 | 2.27 | 37 | 0.27 |
| 25CrMo4 | 0.71 | 1.92 | 30 | 0.23 |
| 30CrNiMo8 | 1.18 | 2.29 | 38 | 0.32 |
| 34Cr4 | 0.67 | 1.96 | 31 | 0.20 |
| 34CrAl6 | 0.75 | 2.08 | 33 | 0.21 |
| 35NiCr18 | 1.38 | 2.26 | 36 | 0.31 |
| 6NiCr6 | 0.80 | 1.86 | 29 | 0.22 |
| 37MnSi5 | 0.52 | 1.74 | 27 | 0.18 |
| 42CrMo4 | 0.66 | 1.90 | 30 | 0.20 |
| 50CrV4 | 0.69 | 1.96 | 31 | 0.20 |
| C15 | 0.50 | 1.64 | 24 | 0.17 |
| C35, C45 | 0.64 | 1.77 | 27 | 0.21 |
| C55, C60 | 0.50 | 1.64 | 24 | 0.17 |
| steel, high temperature | | | | |
| 13CrMo4 5 (1.7335) | 0.72 | 1.88 | 29 | 0.26 |
| 21MoV53 | 0.78 | 1.99 | 32 | 0.27 |
| 22Mo4 | 0.57 | 1.66 | 25 | 0.22 |
| 28NiCrMo4 | 0.72 | 1.73 | 26 | 0.23 |
| steel, low temperature | | | | |
| 15NiMn6 (1.6228) | 0.72 | 1.75 | 26 | 0.21 |
| A514(A) | 0.64 | 1.80 | 28 | 0.22 |
| ASt35 (1.0346) | 0.50 | 1.65 | 24 | 0.17 |
| X12CrNi 18 9 | 4.60 | 6.82 | 136 | 0.81 |
| X12Ni5 (1.5680) | 0.71 | 1.68 | 25 | 0.20 |
| X8Ni9 | 1.86 | 2.25 | 35 | 0.38 |
| steel, spring | | | | |
| 38Si6 | 0.52 | 1.76 | 27 | 0.18 |
| 50CrV4 | 0.72 | 2.02 | 33 | 0.21 |
| 55Si7 | 0.53 | 1.77 | 27 | 0.18 |
| 67SiCr5 | 0.59 | 1.86 | 29 | 0.19 |

*Table 1.2 Metals, Non-ferrous, production, cradle -to-gate*

| metals (per kg)<br>Idemat2010 | eco-costs<br>euro | carbon footprint<br>kg $CO_2$ eq | CED<br>MJ | recipe<br>Pt |
|---|---|---|---|---|
| Aluminium (primary) | 4.03 | 12.23 | 194 | 1.09 |
| Aluminium (secondary) | 0.37 | 1.38 | 24 | 0.14 |
| Aluminium trade mix (65% primary 35% secundary) | 2.75 | 8.43 | 134 | 0.76 |
| Antimony | 9.79 | 12.87 | 141 | 7.83 |
| Cadmium | 2.54 | 0.80 | 17 | 0.08 |
| Chromium | 15.61 | 26.68 | 577 | 2.51 |
| Cobalt | 55.32 | 8.29 | 128 | 0.99 |
| Copper (primary) | 5.07 | 2.34 | 44 | 1.40 |
| Copper (secundary) | 0.86 | 1.79 | 28 | 0.31 |
| Copper trade mix ( 56% primary 44% secundary) | 3.22 | 2.10 | 37 | 0.92 |
| Ferrochromium | 9.35 | 11.06 | 236 | 0.96 |
| Gallium | 618.99 | 209.91 | 3098 | 18.00 |
| Gold | 21105.05 | 13137.67 | 218202 | 7014.36 |
| Indium | 6939.22 | 153.94 | 2573 | 23.07 |
| Lead (primary) | 1.82 | 2.12 | 25 | 0.46 |
| Lead (secundary) | 0.22 | 0.65 | 12 | 0.08 |
| Lead, trade mix ( 44% primary 56% secundary) | 0.92 | 1.30 | 18 | 0.25 |
| Lithium | 65.24 | 21.11 | 415 | 1.97 |
| Magnesium (primary) | 13.43 | 73.76 | 265 | 3.75 |
| Magnesium (secundary) | 0.38 | 2.06 | 44 | 0.18 |
| Magnesium trade mix (57% primary 43% secundary) | 7.82 | 42.93 | 170 | 2.21 |
| Manganese | 0.87 | 2.59 | 59 | 0.42 |
| Molybdenum | 19.31 | 7.61 | 151 | 13.69 |
| Nickel (primary) | 22.16 | 10.86 | 187 | 3.46 |
| Nickel (secundary) | 0.28 | 1.69 | 15 | 0.12 |
| Nickel trade mix (70% primary 30% secundary) | 15.59 | 8.11 | 135 | 2.46 |
| Palladium (market mix) | 54424.70 | 9724.02 | 181514 | 7494.77 |
| Palladium (primary) | 72207.39 | 9722.61 | 176650 | 9908.20 |
| Palladium (secundary) | 141.46 | 757.84 | 14245 | 69.23 |
| Platinum (market mix) | 47814.41 | 14805.77 | 287795 | 5866.50 |
| Platinum (primary) | 114121.09 | 14467.80 | 262865 | 14824.92 |
| Platinum (secundary) | 141.43 | 757.70 | 14242 | 69.22 |
| Rhodium (market mix) | 85370.41 | 28974.44 | 562193 | 11856.18 |
| Rhodium (primary) | 235788.30 | 31689.50 | 575750 | 32303.50 |
| Rhodium (secundary) | 142.56 | 763.73 | 14355 | 69.77 |
| Silicon | 2.20 | 11.07 | 237 | 0.94 |
| Silver | 222.37 | 100.51 | 1480 | 36.20 |
| Tantalum | 207.26 | 259.58 | 4358 | 31.94 |
| Tellurium | 18.36 | 7.51 | 157 | 3.85 |

| | | | | |
|---|---|---|---|---|
| Tin | 17.21 | 17.10 | 321 | 3.78 |
| Titanium (primary) | 27.82 | 95.17 | 2044 | 8.09 |
| Titanium (secundary) | 3.01 | 16.93 | 364 | 1.44 |
| Titanium trade mix (70% primary, 30% secundary) | 20.38 | 71.70 | 1540 | 6.09 |
| Tungsten | 7.22 | 39.77 | 853 | 3.39 |
| Vanadium | 40.98 | 69.51 | 1493 | 5.91 |
| Zinc (primary) | 2.66 | 3.38 | 56 | 0.53 |
| Zinc (secundary) | 0.17 | 0.90 | 19 | 0.08 |
| Zinc trade mix (70% primary 30% secundary) | 1.92 | 2.63 | 45 | 0.39 |

*Table 1.3 Non-ferrous alloys, production, cradle-to-gate*

| metals (per kg)<br>Idemat 2010 | eco-costs<br>euro | carbon footprint<br>kg $CO_2$ eq | CED<br>MJ | recipe<br>Pt |
|---|---|---|---|---|
| aluminium alloys | | | | |
| Al99 | 2.75 | 8.43 | 134 | 0.76 |
| AlCuMg1 (2017) | 2.78 | 8.38 | 131 | 0.77 |
| AlCuMg2 (2024) | 2.83 | 8.64 | 130 | 0.79 |
| AlCuMgPb (2011) | 2.87 | 8.55 | 131 | 0.80 |
| AlCuSiMg (2036) | 2.75 | 8.26 | 132 | 0.76 |
| AlMg1 (5005) | 2.80 | 8.78 | 135 | 0.77 |
| AlMg3 (5754a) | 2.84 | 9.26 | 132 | 0.78 |
| AlMg4.5Mn (5182) | 2.97 | 9.96 | 136 | 0.82 |
| AlMgSi0.5 (6060) | 3.22 | 11.05 | 153 | 0.91 |
| AlMgSi0.7 (6005) | 2.78 | 8.66 | 135 | 0.77 |
| AlMn1 (3003) | 2.73 | 8.38 | 134 | 0.76 |
| AlMn1.2Mg1 (3004) | 2.78 | 8.71 | 134 | 0.77 |
| AlSiMgMn (6009) | 2.77 | 8.65 | 136 | 0.77 |
| AlZnCuMg (7075) | 2.84 | 8.83 | 129 | 0.78 |
| G-AlCu4TiMg (204) | 2.77 | 8.20 | 130 | 0.77 |
| G-AlMg3 (242) | 2.88 | 9.44 | 135 | 0.80 |
| G-AlMg5 (314) | 3.00 | 9.93 | 133 | 0.83 |
| G-AlSi12 (230) | 2.67 | 8.68 | 146 | 0.78 |
| G-AlSi12Cu (231) | 2.68 | 8.72 | 145 | 0.78 |
| G-AlSi7Mg (Thixo) | 2.72 | 8.69 | 141 | 0.78 |
| G-AlSi8Cu3 (380) | 2.69 | 8.38 | 138 | 0.77 |
| copper alloys | | | | |
| Cu-E | 3.22 | 2.10 | 37 | 0.92 |
| CuAg-E | 3.44 | 2.20 | 38 | 0.96 |
| CuAl5 | 3.28 | 2.49 | 43 | 0.92 |
| CuNi10Fe | 4.40 | 2.69 | 47 | 1.06 |
| CuNi18Zn | 5.19 | 3.28 | 56 | 1.09 |
| CuNi44Mn | 8.63 | 4.74 | 80 | 1.59 |
| CuSn6.7P | 4.15 | 3.10 | 56 | 1.11 |
| CuSn8 | 4.34 | 3.30 | 60 | 1.15 |
| CuZn15 | 3.02 | 2.18 | 38 | 0.84 |
| CuZn30 | 2.83 | 2.26 | 39 | 0.76 |
| CuZn37 | 2.74 | 2.29 | 40 | 0.72 |
| CuZn40 | 2.70 | 2.31 | 40 | 0.71 |
| CuZn40Pb | 2.67 | 2.31 | 40 | 0.70 |
| G-CuAl10Fe | 3.09 | 2.71 | 46 | 0.88 |
| G-CuAl10Ni | 3.73 | 3.04 | 51 | 0.95 |

| | | | | |
|---|---|---|---|---|
| G-CuNi10 | 4.39 | 2.71 | 47 | 1.06 |
| G-CuSn10 | 4.62 | 3.60 | 65 | 1.21 |
| G-CuSn12 | 4.90 | 3.90 | 71 | 1.26 |
| G-CuSn5Zn5Pb5 | 3.78 | 2.87 | 51 | 1.01 |
| G-CuZn15 | 3.02 | 2.18 | 38 | 0.84 |
| G-CuZn37Pb | 2.71 | 2.33 | 40 | 0.72 |
| G-CuZn40 | 2.70 | 2.31 | 40 | 0.71 |
| magnesium alloys | | | | |
| AM100A | 7.30 | 39.44 | 166 | 2.07 |
| AM503 | 7.73 | 42.44 | 169 | 2.19 |
| G-MgAl6Zn3 | 7.33 | 39.61 | 164 | 2.07 |
| G-MgAl8Zn1 | 7.38 | 39.97 | 166 | 2.09 |
| G-MgAl9Zn2 | 7.24 | 38.98 | 164 | 2.04 |
| GD-MgAl9Zn1 | 7.31 | 39.49 | 166 | 2.07 |
| MgAl3Zn | 7.59 | 41.41 | 167 | 2.15 |
| MgAl6Zn | 7.42 | 40.22 | 166 | 2.10 |
| MgMn1.5 | 7.71 | 42.32 | 168 | 2.19 |
| MgZn6Zr | 7.50 | 40.71 | 163 | 2.11 |
| nickel alloys | | | | |
| Duranik | 14.96 | 8.53 | 145 | 2.39 |
| Invar | 7.37 | 8.32 | 135 | 1.37 |
| Mumetal | 12.61 | 7.44 | 128 | 2.04 |
| Ni 99.6 | 15.59 | 8.11 | 135 | 2.46 |
| Ni span C902 | 8.12 | 7.39 | 137 | 1.40 |
| NiCr 80 20 | 15.60 | 11.82 | 224 | 2.47 |
| NiCr20Co18Ti | 21.96 | 13.27 | 254 | 2.27 |
| NiCr20TiAl | 15.51 | 13.38 | 258 | 2.53 |
| NiCu30Al | 12.62 | 10.55 | 197 | 2.29 |
| NiCu30Fe | 11.39 | 6.08 | 102 | 1.93 |
| NiFe 50 50 | 8.04 | 4.86 | 79 | 1.31 |
| NiMo30 | 17.45 | 8.25 | 146 | 5.54 |
| Supermalloy | 12.76 | 6.78 | 114 | 2.56 |
| Titanium alloys | | | | |
| TiAl5Sn2 | 19.42 | 67.17 | 1439 | 5.77 |
| TiAl6V4 | 20.15 | 67.81 | 1454 | 5.77 |
| TiV15SnCrAl3 | 22.70 | 66.48 | 1425 | 5.73 |
| Zinc alloys | | | | |
| G-ZnAlCu | 1.53 | 2.31 | 40 | 0.33 |
| Zamak3 | 1.50 | 2.32 | 40 | 0.32 |
| Zamak5 | 1.51 | 2.32 | 40 | 0.32 |
| Zinc (super plastic) | 1.61 | 3.09 | 52 | 0.37 |
| ZnCuTi | 1.62 | 2.65 | 48 | 0.35 |

# 1.2 Metals, processing (gate-to-gate)

*Table 1.4 Metals, processing, eco-costs, gate-to-gate*

| metals<br>processing<br>eco-costs (euro/kg)<br>Idemat 2010, estimates | casting | forging | metal powder forming | vaporisation | conventional machining (per unit wt removed) | non-conv machining (per unit wt removed) |
|---|---|---|---|---|---|---|
| Cast iron, ductile | 0.04 | 0.04 | 0.46 | 0.31 | 0.09 | 0.62 |
| Cast iron, gray | 0.04 | 0.03 | 0.47 | 0.32 | 0.06 | 0.66 |
| High carbon steel | 0.04 | 0.05 | 0.53 | 0.35 | 0.14 | 0.73 |
| Low alloy steel | 0.04 | 0.05 | 0.56 | 0.37 | 0.15 | 0.76 |
| Low carbon steel | 0.05 | 0.03 | 0.58 | 0.39 | 0.13 | 0.76 |
| Medium carbon steel | 0.05 | 0.04 | 0.56 | 0.37 | 0.13 | 0.76 |
| Stainless steel | 0.04 | 0.05 | 0.55 | 0.37 | 0.23 | 0.73 |
| Age-hardening wrought Al-alloys | 0.03 | 0.05 | 0.32 | 0.24 | 0.12 | 0.50 |
| Cast Al-alloys | 0.03 | 0.04 | 0.32 | 0.25 | 0.08 | 0.50 |
| Non age-hardening wrought Al-alloys | 0.03 | 0.04 | 0.35 | 0.26 | 0.13 | 0.54 |
| Brass | 0.03 | 0.03 | 0.32 | 0.22 | 0.12 | 0.44 |
| Bronze | 0.03 | 0.03 | 0.34 | 0.23 | 0.10 | 0.47 |
| Copper | 0.03 | 0.03 | 0.36 | 0.25 | 0.09 | 0.48 |
| Commercially pure lead | 0.01 | 0.02 | 0.08 | 0.07 | 0.06 | 0.14 |
| Lead alloys | 0.00 | 0.02 | 0.06 | 0.06 | 0.06 | 0.12 |
| Cast magnesium alloys | 0.03 | 0.04 | 0.32 | 0.24 | 0.09 | 0.50 |
| Wrought magnesium alloys | 0.03 | 0.06 | 0.32 | 0.24 | 0.13 | 0.50 |
| Nickel | 0.04 | 0.04 | 0.55 | 0.36 | 0.13 | 0.71 |
| Nickel-based superalloys | 0.04 | 0.05 | 0.50 | 0.33 | 0.19 | 0.68 |
| Nickel-chromium alloys | 0.04 | 0.04 | 0.51 | 0.34 | 0.13 | 0.68 |
| Tin | 0.00 | 0.02 | 0.06 | 0.06 | 0.06 | 0.12 |
| Commercially pure titanium | 0.06 | 0.05 | 0.69 | 0.45 | 0.12 | 0.88 |
| Titanium alloys | 0.06 | 0.07 | 0.72 | 0.47 | 0.12 | 0.94 |
| Tungsten alloys | 0.07 | 0.04 | 0.83 | 0.52 | 0.10 | 1.03 |
| Commercially pure zinc | 0.01 | 0.03 | 0.14 | 0.12 | 0.09 | 0.23 |
| Zinc die-casting alloys | 0.01 | 0.03 | 0.16 | 0.13 | 0.10 | 0.27 |

*Table 1.5 Metals, ferro and non-ferro, processing, gate-to-gate*

| processing metals (per kg)<br>Idemat 2010 | unit | eco-costs<br>euro | carbon footprint<br>kg $CO_2$ eq | CED<br>MJ | recipe<br>Pt |
|---|---|---|---|---|---|
| Processing, ferro | | | | | |
| Drilling steel (per kg removed, the removed steel not counted) | kg | 0.29 | 1.49 | 19 | 0.13 |
| Electric MIG welding 4 | kg | 0.25 | 1.26 | 24 | 0.11 |
| Electroplating Chrome | m2 | 2.14 | 2.86 | 61 | 0.31 |
| Electroplating Nickel | m2 | 1.38 | 1.88 | 38 | 0.25 |
| Electroplating Zinc, incl. use, outside, per 10 years | m2 | 59.94 | 3.08 | 65 | 0.28 |
| Electroplating Zinc, inside use (5 micron) | m2 | 1.10 | 1.54 | 33 | 0.14 |
| Milling steel (per kg removed, revomed steel not counted) | kg | 0.36 | 1.83 | 26 | 0.16 |
| Phosphating (Fe s) | m2 | 0.18 | 0.73 | 16 | 0.06 |
| Phosphating (Zn i) | m2 | 0.11 | 0.01 | 0 | 0.00 |
| Phosphating (Zn s) | m2 | 0.05 | 0.01 | 0 | 0.00 |
| Rolling steel | kg | 0.03 | 0.05 | 1 | 0.00 |
| Turrning steel (per kg removed, steel removed not counted) | kg | 0.31 | 1.59 | 21 | 0.14 |
| welding (per meter) | | | | | |
| welding steel arc | m | 0.06 | 0.12 | 2 | 0.01 |
| welding steel, gas | m | 0.07 | 0.15 | 2 | 0.02 |
| Processing, non-ferro | | | | | |
| Anodising per m2 | m2 | 0.23 | 1.06 | 32 | 0.11 |
| Autogenuous welding Al 1 per m | m2 | 0.11 | 0.64 | 14 | 0.05 |
| Autogenuous welding Al 2 per m | m2 | 0.31 | 1.75 | 38 | 0.15 |
| Autogenuous welding Al 3 per m | m2 | 0.49 | 2.74 | 59 | 0.23 |
| Cold transforming Al per kg | kg | 0.02 | 0.11 | 2 | 0.01 |
| Cutting Al. Laser | m2 | 0.03 | 0.17 | 4 | 0.01 |
| Al. Shears | m2 | 0.12 | 0.66 | 14 | 0.06 |
| Al. (per kg removed, removed Al not counted | kg | 0.33 | 1.68 | 23 | 0.15 |
| Extruding alum | kg | 0.14 | 0.74 | 11 | 0.06 |
| Forging aluminium | kg | 0.04 | 0.24 | 5 | 0.02 |
| Machining aluminium | kg | 0.02 | 0.09 | 2 | 0.01 |
| MIG-arc welding Al 10 | m | 0.64 | 3.62 | 78 | 0.31 |
| MIG-arc welding Al 12 | m | 1.13 | 6.36 | 137 | 0.54 |
| MIG-arc welding Al 4 | m | 0.12 | 0.70 | 15 | 0.06 |
| MIG-arc welding Al 5 I-jnt | m | 0.27 | 1.52 | 33 | 0.13 |
| MIG-arc welding Al 5 V-jnt | m | 0.41 | 2.27 | 49 | 0.19 |
| MIG-arc welding Al 6 V-jnt | m | 0.48 | 2.70 | 58 | 0.23 |
| MIG-arc welding Al 8 | m | 0.61 | 3.44 | 74 | 0.29 |
| Milling Al. (per kg removed, removed Al not counted) | kg | 0.35 | 1.76 | 25 | 0.16 |
| Rolling aluminium foil | kg | 0.19 | 0.96 | 17 | 0.08 |
| Rolling aluminium sheet | kg | 0.15 | 0.79 | 13 | 0.07 |
| Rolling brass | kg | 0.07 | 0.38 | 5 | 0.03 |
| Sawing Al. band saw | m2 | 0.08 | 0.44 | 9 | 0.04 |

| | | | | | |
|---|---|---|---|---|---|
| Sawing Al. circular saw | m2 | 0.16 | 0.87 | 19 | 0.07 |
| Scouring aluminium | kg | 0.16 | 0.92 | 20 | 0.08 |
| Seam welding Al. 0.25 | m | 0.52 | 2.92 | 63 | 0.25 |
| Seam welding Al. 1.5 | m | 1.66 | 9.33 | 201 | 0.79 |
| Seam welding Al. 2.5 | m | 2.39 | 13.41 | 288 | 1.14 |
| Spot welding Al. 0.5 | p | 0.01 | 0.03 | 1 | 0.00 |
| Spot welding Al. 1 | p | 0.01 | 0.06 | 1 | 0.00 |
| Spot welding Al. 1.5 | p | 0.02 | 0.12 | 3 | 0.01 |
| Spot welding Al. 3 | p | 0.05 | 0.27 | 6 | 0.02 |
| Turning Al (per kg removed, removed Al not counted) | kg | 0.52 | 2.64 | 44 | 0.24 |

## 1.3 Metals, End of Life

*Table 1.6 Metals, recycling credits closed loop*

| metals (per kg)<br>Idemat 2010 | eco-costs<br>euro | carbon footprint<br>kg $CO_2$ eq | CED<br>MJ | recipe<br>Pt |
|---|---|---|---|---|
| Aluminium, recycling credit closed loop (65% virgin in market mix) | -2,38 | -7,05 | -111 | -0,62 |
| Copper, recycling credit closed loop (56% virgin in market mix) | -2,36 | -0,31 | -9 | -0,61 |
| Lead, recycling credit closed loop (44% virgin in market mix) | -0,71 | -0,64 | -6 | -0,17 |
| Magnesium, recycling credit closed loop (57% virgin in market mix) | -7,44 | -40,87 | -126 | -2,04 |
| Nickel, recycling credit closed loop (70% virgin in market mix) | -15,32 | -6,42 | -121 | -2,34 |
| Steel, recycling credit closed loop (79% virgin in market mix) | -0,23 | -0,86 | -11 | -0,08 |
| Titanium, recycling credit closed loop (70% virgin in market mix) | -17,37 | -54,77 | -1176 | -4,66 |
| Zinc, recycling credit closed loop (70% virgin in market mix) | -1.74 | -1.74 | -26.09 | -0.32 |

*Table 1.7 Metals, landfill and open loop recycling*

| metals (per kg)<br>Idemat 2010 | eco-costs<br>euro | carbon footprint<br>kg CO2 eq | CED<br>MJ | recipe<br>Pt |
|---|---|---|---|---|
| landfill | 0,118 | - | - | - |
| waste handling aluminium scrap | 0,049 | 0,253 | 3,3 | 0,024 |
| waste handling iron scrap | 0,010 | 0,042 | 0,7 | 0,005 |
| waste handling scrap other metals | 0,025 | 0,065 | 0,9 | 0,006 |

# 1.4 Polymers, production (cradle-to-gate)

*Table 1.8 Polymers, production, cradle-to-gate*

| polymers (per kg) | eco-costs | carbon footprint | CED | recipe |
|---|---|---|---|---|
| Idemat 2010 | euro | kg $CO_2$ eq | MJ | Pt |
| elastomers | | | | |
| BR and PIB (butadiene rubber and butyl rubber) | 0.920 | 1.45 | 85 | 0.28 |
| EPDM | 1.226 | 2.65 | 91 | 0.36 |
| EVA (ethylene vinyl acetate) estimate | 1.144 | 3.05 | 66 | 0.26 |
| Natural rubber | 0.098 | 0.21 | 3 | 0.02 |
| NBR | 0.996 | 1.82 | 83 | 0.29 |
| Polychloroprene (Neoprene, CR) estimate | 1.103 | 3.70 | 80 | 0.31 |
| Polyisoprene rubber (IIR) estimate | 1.126 | 2.28 | 49 | 0.19 |
| Silicone rubber | 0.761 | 2.71 | 63 | 0.28 |
| Styrene butadiene rubber (SBR) | 1.002 | 2.00 | 87 | 0.31 |
| thermoplasts | | | | |
| ABS | 1.33 | 3.40 | 87 | 0.36 |
| ABS 30% glass fibre | 0.97 | 2.52 | 63 | 0.27 |
| Cellulose polymers, natural source, estimate | 0.83 | 4.66 | 100 | 0.40 |
| Ionomer estimate | 1.45 | 4.20 | 90 | 0.36 |
| Moulded Recycled Plastic | 0.33 | 1.75 | 37 | 0.17 |
| PA 6 | 2.09 | 9.27 | 122 | 0.76 |
| PA 6 GF30 | 1.49 | 6.63 | 88 | 0.55 |
| PA 66 | 1.92 | 8.01 | 137 | 0.72 |
| PA 66 GF30 | 1.38 | 5.75 | 99 | 0.52 |
| PB | 1.12 | 1.30 | 81 | 0.25 |
| PC | 1.97 | 7.78 | 108 | 0.67 |
| PC 30% glass fibre | 1.41 | 5.59 | 78 | 0.49 |
| PE (HDPE) | 1.03 | 1.93 | 77 | 0.28 |
| PE (LDPE) | 1.06 | 2.10 | 80 | 0.29 |
| PE (LLDPE) | 1.01 | 1.85 | 75 | 0.27 |
| PE expanded | 1.06 | 2.12 | 84 | 0.30 |
| PET 30% glass fibre | 0.78 | 2.17 | 60 | 0.26 |
| PET amorph | 1.02 | 2.70 | 78 | 0.33 |
| PET bottle grade | 1.07 | 2.89 | 82 | 0.35 |
| PMMA | 1.78 | 7.12 | 129 | 0.68 |
| Polyetheretherketone (PEEK), estimate | 3.02 | 13.42 | 288 | 1.14 |
| Polyhydroxyalkanoates (PHA, PHB), estimate | 0.44 | 2.47 | 53 | 0.21 |
| Polylactide (PLA, starch based biodegradeble plastic) | 0.67 | 3.12 | 78 | 0.33 |
| Polytetrafluoroethylene (Teflon, PTFE), estimate | 1.79 | 7.48 | 161 | 0.64 |
| POM (Polyoxymethyleen, polyacetaal), estimate | 1.04 | 4.02 | 86 | 0.34 |
| PP | 1.03 | 1.97 | 75 | 0.28 |
| PP GF30 | 0.75 | 1.52 | 55 | 0.21 |
| PS (EPS) | 1.31 | 3.38 | 90 | 0.39 |

| | | | | |
|---|---|---|---|---|
| PS (GPPS) | 1.33 | 3.50 | 88 | 0.39 |
| PS (HIPS) | 1.34 | 3.50 | 88 | 0.39 |
| PVC | 0.65 | 2.01 | 61 | 0.22 |
| PVC (b) | 0.65 | 1.99 | 61 | 0.22 |
| PVC (e) | 0.74 | 2.51 | 68 | 0.27 |
| PVC (s) | 0.63 | 1.91 | 59 | 0.22 |
| PVDC | 1.25 | 4.90 | 81 | 0.47 |
| SAN | 1.44 | 4.06 | 96 | 0.43 |
| Starch-based thermoplastics (TPS) | 0.43 | 2.01 | 60 | 0.27 |
| thermosets | | | | |
| Epoxy resin | 2.01 | 6.73 | 135 | 0.73 |
| MF (resin) | 0.95 | 3.42 | 78 | 0.39 |
| PF (resin) | 0.83 | 2.94 | 94 | 0.38 |
| Phenolics (Bakelite) | 0.88 | 3.27 | 102 | 0.41 |
| Polyester (unsat) | 1.97 | 7.46 | 123 | 0.67 |
| PUR flex. block foam | 1.56 | 4.97 | 111 | 0.52 |
| PUR flex. moulded MDI/TDI | 1.49 | 4.67 | 109 | 0.50 |
| PUR flex. moulded TDI | 1.53 | 4.84 | 110 | 0.51 |
| PUR flex. moulded. MDI | 1.37 | 4.18 | 105 | 0.46 |
| PUR rigid foam | 1.33 | 4.26 | 103 | 0.46 |
| PUR rigid integr. skin foam | 1.16 | 4.31 | 103 | 0.46 |
| PUR semi rigid foam | 1.23 | 4.84 | 103 | 0.49 |
| SMC and DMC 25% GL | 0.55 | 2.02 | 34 | 0.19 |
| SMC and DMC 50% GL | 0.48 | 1.76 | 30 | 0.17 |
| UF (resin) | 0.58 | 2.20 | 56 | 0.26 |
| recycled polymers | | | | |
| EVA, recycled (estimate) | 0.27 | 1.38 | 29 | 0.12 |
| Flexible Polymeer Foam, recycled (estimate) | 0.41 | 2.20 | 47 | 0.19 |
| ABS, recycled (estimate) | 0.30 | 1.55 | 33 | 0.13 |
| Cellelose polymers, recycled (estimate) | 0.39 | 2.06 | 44 | 0.18 |
| Ionomer, recycled (estimate) | 0.35 | 1.86 | 39 | 0.16 |
| PA (Nylons), recycled (estimate) | 0.45 | 2.44 | 52 | 0.21 |
| PC, reclycled (estimate) | 0.46 | 2.49 | 53 | 0.21 |
| PE, recycled (estimate) | 0.19 | 0.97 | 20 | 0.08 |
| PEEK, recycled (estimate) | 1.04 | 5.73 | 123 | 0.49 |
| PET, recycled (estimate) | 0.21 | 1.08 | 23 | 0.09 |
| PHA, PHB, recycled (estimate) | 0.22 | 1.13 | 24 | 0.10 |
| PLA, recycled (estimate) | 0.21 | 1.09 | 23 | 0.09 |
| PMMA (Acrylic), recycled (estimate) | 0.31 | 1.63 | 34 | 0.14 |
| POM, recycled (estimate) | 0.34 | 1.79 | 38 | 0.15 |
| PP, recycled (estimate) | 0.24 | 1.24 | 26 | 0.11 |
| PS, recycled (estimate) | 0.25 | 1.30 | 27 | 0.11 |
| PTFE (Teflon), recycled (estimate) | 0.60 | 3.24 | 69 | 0.28 |
| PUR, recycled (estimate) | 0.41 | 2.18 | 46 | 0.19 |
| PVC, recycled (estimate) | 0.22 | 1.11 | 23 | 0.10 |
| Starch-based thermoplastics, recycled (estimate) | 0.23 | 1.15 | 24 | 0.10 |

## 1.5 Polymers, processing (gate-to-gate)

*Table 1.9 Polymers, processing, eco-costs, gate-to-gate*

| polymers<br>processing<br>eco-costs (euro/kg) | polymer molding | polymer extrusion | polymer machining (per unit wt removed) |
|---|---|---|---|
| Butyl rubber (IIR) | 0.24 | | |
| Ethylene vinyl acetate (EVA) | 0.25 | | |
| Natural rubber (NR) | 0.24 | | |
| Polychloroprene (Neoprene, CR) | 0.25 | | |
| Polyisoprene rubber (IIR) | 0.23 | | |
| Polyurethane (elPU) | 0.24 | | |
| Silicone elastomers (SI, Q) | 0.20 | | |
| Styrene butadiene rubber (SBR) | 0.23 | | |
| Acrylonitrile butadiene styrene (ABS) | 0.34 | 0.13 | 0.03 |
| Cellulose polymers (CA) | 0.29 | 0.11 | 0.03 |
| Ionomer (I) | 0.31 | 0.12 | 0.03 |
| Polyamides (Nylons, PA) | 0.30 | 0.12 | 0.03 |
| Polycarbonate (PC) | 0.33 | 0.15 | 0.03 |
| Polyetheretherketone (PEEK) | 0.37 | 0.14 | 0.03 |
| Polyethylene (PE) | 0.20 | 0.08 | 0.03 |
| Polyethylene terephthalate (PET) | 0.31 | 0.12 | 0.03 |
| Polyhydroxyalkanoates (PHA, PHB) | 0.27 | 0.10 | 0.03 |
| Polylactide (PLA) | 0.28 | 0.11 | 0.03 |
| Polymethyl methacrylate (Acrylic, PMMA) | 0.34 | 0.13 | 0.03 |
| Polyoxymethylene (Acetal, POM) | 0.23 | 0.09 | 0.03 |
| Polypropylene (PP) | 0.27 | 0.10 | 0.03 |
| Polystyrene (PS) | 0.34 | 0.13 | 0.03 |
| Polytetrafluoroethylene (Teflon, PTFE) | 0.30 | 0.12 | 0.03 |
| Polyurethane (tpPUR) | 0.31 | 0.12 | 0.03 |
| Polyvinylchloride (tpPVC) | 0.31 | 0.11 | 0.03 |
| Starch-based thermoplastics (TPS) | 0.28 | 0.11 | 0.03 |
| Epoxies | 0.35 | | 0.03 |
| Phenolics | 0.40 | | 0.03 |
| Polyester | 0.38 | | 0.03 |

*Table 1.10 Polymers, processing, gate-to-gate*

| processing polymers (per kg)<br>Idemat 2010 | eco-costs<br>euro | carbon footprint<br>kg $CO_2$ eq | CED<br>MJ | recipe<br>Pt |
|---|---|---|---|---|
| Blow moulding bottles | 0,21 | 1,09 | 29 | 0,12 |
| Blow moulding UPVC film | 0,13 | 0,50 | 8 | 0,04 |
| Extrusion | 0,12 | 0,42 | 7 | 0,04 |
| Extrusion PVC | 0,11 | 0,39 | 6 | 0,03 |
| Injection moulding | 0,26 | 1,33 | 29 | 0,13 |
| Injection moulding PVC | 0,15 | 0,28 | 38 | 0,07 |
| Recycling mixed polymer | 0,07 | 0,42 | 8 | 0,04 |
| Thermo forming | 0,16 | 0,53 | 12 | 0,06 |

# 1.6 Polymers, End of Life

*Table 1.11 Polymers, recycling credits*

| polymers (per kg)<br>Idemat 2010 | eco-costs<br>euro | carbon footprint<br>kg $CO_2$ eq | CED<br>MJ | recipe<br>Pt |
|---|---|---|---|---|
| ABS, recycling credit | -1.04 | -1.85 | -54 | -0.23 |
| Cellulose polymers (CA), recycling credit | -0.44 | -2.60 | -57 | -0.22 |
| EVA (Ethylene vinyl acetate), recycling credit | -0.88 | -1.67 | -37 | -0.14 |
| Flexible Polymer Foam, recycling credit | -0.81 | -2.63 | -56 | -0.30 |
| Ionomer, recycling credit | -1.10 | -2.34 | -51 | -0.20 |
| PA (nylons, polyamides), recycling credit | -1.63 | -6.83 | -70 | -0.55 |
| PC (Polycarbonate), recycling credit | -1.51 | -5.29 | -55 | -0.46 |
| PE (Polyethylene), recycling credit | -0.83 | -0.96 | -57 | -0.19 |
| PEEK (Polyetheretherketone), credit | -1.98 | -7.69 | -166 | -0.65 |
| PET (Polyethylene terephthalate, recycling credit | -0.86 | -1.81 | -60 | -0.26 |
| PHA, PHB (Polyhydroxyalkanoates), recycling credit | -0.22 | -1.34 | -29 | -0.11 |
| PLA (Polylactide), recycling credit | -0.45 | -2.02 | -55 | -0.24 |
| PMMA, Acrilylic (Polymethyl methacrylate), recycling credit | -1.47 | -5.50 | -94 | -0.54 |
| POM, Acetal (Polyoxymethylene), recycling credit | -0.70 | -2.23 | -49 | -0.19 |
| PP (Polypropylene), recycling credit | -0.79 | -0.73 | -49 | -0.17 |
| PS (Polystyrene), recycle credit | -1.06 | -2.08 | -62 | -0.27 |
| PTFE, Teflon (Polytetrafluoroethylene), recycling credit | -1.19 | -4.24 | -92 | -0.36 |
| PUR (Polyethane), recycling credit | -1.16 | -2.79 | -65 | -0.33 |
| PVC (Polyvinylchloride), recycling credit | -0.43 | -0.89 | -38 | -0.13 |
| Starch-based thermoplastics (TPS), recycling credit | -0.20 | -0.86 | -36 | -0.17 |

Note: these recycling credits are for uncoloured polymers; for coloured polymers see Section A.5.

*Table 1.12 Polymers, combustion in electrical power plants*

| polymers (per kg)<br>Idemat 2010 | eco-costs<br>euro | carbon footprint<br>kg $CO_2$ eq | CED<br>MJ | recipe<br>Pt |
|---|---|---|---|---|
| combustion of elastomers in electrical power plant | | | | |
| Butyl rubber (IIR) | -0.01 | 0.26 | -63 | 0.03 |
| Ethylene vinyl acetate (EVA) | -0.01 | 0.22 | -57 | 0.03 |
| Natural rubber (NR) | -0.51 | -2.89 | -62 | -0.25 |
| Polychloroprene (Neoprene, CR) | 0.02 | 0.28 | -25 | 0.03 |
| Polyisoprene rubber (IIR) | 0.00 | 0.34 | -62 | 0.04 |
| Polyurethane (elPU) | 0.06 | 0.57 | -32 | 0.05 |
| Silicone elastomers (SI, Q) | 0.05 | 0.44 | -19 | 0.04 |
| Styrene butadiene rubber (SBR) | -0.01 | 0.26 | -63 | 0.03 |
| combustion of thermoplastics in electrical power plant | | | | |
| Acrylonitrile butadiene styrene (ABS) | 0.05 | 0.58 | -55 | 0.06 |

| | | | | |
|---|---|---|---|---|
| Cellulose polymers (CA) | -0.22 | -1.25 | -27 | -0.11 |
| Ionomer (I) combustion | 0.00 | 0.27 | -53 | 0.03 |
| Polyamides (Nylons, PA) | 0.01 | 0.29 | -44 | 0.03 |
| Polycarbonate (PC) | 0.08 | 0.71 | -44 | 0.07 |
| Polyetheretherketone (PEEK) | 0.10 | 0.83 | -45 | 0.08 |
| Polyethylene (PE) | -0.03 | 0.15 | -64 | 0.02 |
| Polyethylene terephthalate (PET) | 0.09 | 0.73 | -34 | 0.07 |
| Polyhydroxyalkanoates (PHA, PHB) | -0.28 | -1.56 | -34 | -0.13 |
| Polylactide (PLA) | -0.23 | -1.28 | -28 | -0.11 |
| Polymethyl methacrylate (Acrylic, PMMA) | 0.04 | 0.44 | -38 | 0.04 |
| Polyoxymethylene (Acetal, POM) | 0.05 | 0.42 | -23 | 0.04 |
| Polypropylene (PP) | -0.03 | 0.15 | -64 | 0.02 |
| Polystyrene (PS) | 0.05 | 0.63 | -59 | 0.06 |
| Polytetrafluoroethylene (Teflon, PTFE) | 0.08 | 0.56 | -7 | 0.05 |
| Polyurethane (tpPUR) | 0.06 | 0.57 | -32 | 0.05 |
| Polyvinylchloride (tpPVC) | 0.01 | 0.22 | -26 | 0.02 |
| Starch-based thermoplastics (TPS) | -0.20 | -1.13 | -24 | -0.10 |
| combustion of thermosets in electrical power plant | | | | |
| Epoxies | 0.03 | 0.44 | -44 | 0.05 |
| Phenolics (Bakelite) | 0.09 | 0.79 | -46 | 0.08 |
| Polyester | 0.07 | 0.65 | -41 | 0.06 |
| combustion, others | | | | |
| CFRP combustion in electrical power plant | 0.14 | 1.12 | -46 | 0.11 |
| DMC combustion in electrical power plant | 0.04 | 0.33 | -20 | 0.03 |
| Flexible Polymer Foam, combustion in electrical power plant | -0.03 | 0.15 | -64 | 0.02 |
| GFRP combustion in electrical power plant | 0.01 | 0.18 | -18 | 0.02 |
| Rigid Polymer Foam, combustion in electrical power plant | 0.01 | 0.22 | -26 | 0.02 |
| SMC combustion in electrical power plant | 0.04 | 0.33 | -20 | 0.03 |

*Table 1.13 Polymers, municipal waste incineration with electricity*

| polymers (per kg) | eco-costs | carbon footprint | CED | recipe |
|---|---|---|---|---|
| Idemat 2010 | euro | kg $CO_2$ eq | MJ | Pt |
| waste incineration of elastomers with electricity | | | | |
| Butyl rubber (IIR) | 0.22 | 1.58 | -35 | 0.14 |
| Ethylene vinyl acetate (EVA) | 0.20 | 1.42 | -32 | 0.13 |
| Natural rubber (NR) | -0.28 | -1.59 | -34 | -0.14 |
| Polychloroprene (Neoprene, CR) | 0.12 | 0.79 | -14 | 0.07 |
| Polyisoprene rubber (IIR) | 0.24 | 1.64 | -34 | 0.15 |
| Polyurethane (elPU) | 0.18 | 1.24 | -18 | 0.11 |
| Silicone elastomers (SI, Q) | 0.13 | 0.84 | -11 | 0.08 |
| Styrene butadiene rubber (SBR) | 0.22 | 1.58 | -35 | 0.14 |

| | | | | |
|---|---|---|---|---|
| waste incineration of thermopastics with electricity | | | | |
| Acrylonitrile butadiene styrene (ABS) | 0.25 | 1.74 | -30 | 0.16 |
| Cellulose polymers (CA) | -0.12 | -0.69 | -15 | -0.06 |
| Ionomer (I) | 0.20 | 1.39 | -29 | 0.13 |
| Polyamides (Nylons, PA) | 0.18 | 1.22 | -24 | 0.11 |
| Polycarbonate (PC) | 0.24 | 1.64 | -24 | 0.15 |
| Polyetheretherketone (PEEK) | 0.26 | 1.76 | -25 | 0.16 |
| Polyethylene (PE) | 0.21 | 1.50 | -35 | 0.14 |
| Polyethylene terephthalate (PET) | 0.21 | 1.43 | -19 | 0.13 |
| Polyhydroxyalkanoates (PHA, PHB) | -0.15 | -0.86 | -18 | -0.07 |
| Polylactide (PLA) | -0.13 | -0.70 | -15 | -0.06 |
| Polymethyl methacrylate (Acrylic, PMMA) | 0.18 | 1.23 | -21 | 0.11 |
| Polyoxymethylene (Acetal, POM) | 0.13 | 0.89 | -12 | 0.08 |
| Polypropylene (PP) | 0.21 | 1.50 | -35 | 0.14 |
| Polystyrene (PS) | 0.27 | 1.87 | -32 | 0.17 |
| Polytetrafluoroethylene (Teflon, PTFE) | 0.11 | 0.71 | -4 | 0.06 |
| Polyurethane (tpPUR) | 0.18 | 1.24 | -18 | 0.11 |
| Polyvinylchloride (tpPVC) | 0.11 | 0.76 | -14 | 0.07 |
| Starch-based thermoplastics (TPS) | -0.11 | -0.62 | -13 | -0.05 |
| waste incineration of thermosets with electricity | | | | |
| Epoxies | 0.20 | 1.36 | -24 | 0.12 |
| Phenolics (Bakelite) | 0.26 | 1.75 | -25 | 0.16 |
| Polyester | 0.22 | 1.50 | -23 | 0.14 |
| combustion, others | | | | |
| CFRP waste incineration with electricity | 0.31 | 2.08 | -25 | 0.19 |
| DMC waste incineration with electricity | 0.11 | 0.76 | -11 | 0.07 |
| Flexible Polymer Foam, waste incineration with electricity | 0.21 | 1.50 | -35 | 0.14 |
| GFRP waste incineration with electricity | 0.08 | 0.54 | -10 | 0.05 |
| Rigid Polymer Foam, waste incineration with electricity | 0.11 | 0.76 | -14 | 0.07 |
| SMC waste incineration with electricity | 0.11 | 0.76 | -11 | 0.07 |

*Table 1.14 Polymers, landfill*

| polymers (per kg) | eco-costs | carbon footprint | CED | recipe |
|---|---|---|---|---|
| Idemat 2010 | euro | kg $CO_2$ eq | MJ | Pt |
| landfill | 0.118 | - | - | - |

# 1.7 Wood, Wood products, and Paper, production (cradle-to-gate)

*Table 1.15 Wood, woodproducts, and paper, cradle-to-gate (port in the North Sea area)*

| Wood, Wood products, and Paper (per kg)<br>Idemat 2010 | eco-costs<br>euro | carbon footprint<br>kg $CO_2$ eq | CED<br>MJ | recipe<br>Pt |
|---|---|---|---|---|
| hardwood, durability Class I | | | | |
| Teak plantation | 0.214 | 0.739 | 13.1 | 0.076 |
| Teak FSC | 1.704 | 0.739 | 13.1 | 0.076 |
| Teak natural forest | 7.674 | 0.739 | 13.1 | 0.076 |
| hardwood, durability Class II | | | | |
| Azobe plantation | 0.094 | 0.488 | 9.1 | 0.047 |
| Azobe FSC | 0.864 | 0.488 | 9.1 | 0.047 |
| Azobe natural forest | 3.964 | 0.488 | 9.1 | 0.047 |
| Cedar plantation | 0.166 | 0.644 | 11.5 | 0.064 |
| Cedar FSC | 2.206 | 0.644 | 11.5 | 0.064 |
| Cedar natural forest | 10.386 | 0.644 | 11.5 | 0.064 |
| Chestnut | 0.068 | 0.459 | 8.5 | 0.041 |
| Mahogany, American plantation | 0.149 | 0.610 | 11.0 | 0.060 |
| Mahogany, American FSC | 1.539 | 0.610 | 11.0 | 0.060 |
| Mahogany, American natural forest | 7.099 | 0.610 | 11.0 | 0.060 |
| Meranti plantation | 0.268 | 0.855 | 14.9 | 0.089 |
| Meranti FSC | 2.148 | 0.855 | 14.9 | 0.089 |
| Meranti natural forest | 9.668 | 0.855 | 14.9 | 0.089 |
| Merbau plantation | 0.272 | 0.864 | 15.0 | 0.090 |
| Merbau FSC | 1.162 | 0.864 | 15.0 | 0.090 |
| Merbau natural forest | 4.702 | 0.864 | 15.0 | 0.090 |
| european wood, durability Class III | | | | |
| Scotspine (grenen) | 0.022 | 0.031 | -0.9 | 0.005 |
| Walnut | 0.057 | 0.431 | 8.1 | 0.038 |
| wood, durability Class IV | | | | |
| Okoume plantation | 0.165 | 0.638 | 11.5 | 0.064 |
| Okoume FSC | 2.135 | 0.638 | 11.5 | 0.064 |
| Okoume natural forrest | 9.995 | 0.638 | 11.5 | 0.064 |
| Spruce, European | 0.067 | 0.302 | 3.1 | 0.029 |
| Beech, European | 0.021 | 0.063 | -0.5 | 0.007 |
| Poplar | 0.032 | 0.364 | 7.1 | 0.032 |
| Willow | 0.014 | 0.316 | 6.5 | 0.027 |
| wood products | | | | |
| Acetylated Scots pine = durable wood, s.g. 590 kg/$m^3$, estimate | 0.166 | 0.052 | 4.9 | 0.017 |

| | | | | |
|---|---|---|---|---|
| Cork at factory gate in Portugal | 0.039 | 0.110 | 20.3 | 0.139 |
| Fibreboard hard (800 kg/m3) | 0.142 | 0.754 | 44.1 | 0.092 |
| MDF (750 kg/m3) | 0.148 | 0.689 | 40.1 | 0.092 |
| Particle Board, chipboard, indoor (600 kg/m3) | 0.146 | 0.697 | 36.9 | 0.088 |
| Plato wood = thermal treated European Spruce, s.g. 420 kg/m3 | 0.153 | 0.765 | 11.2 | 0.071 |
| Plywood Bamboo (density approx 700 kg/m3) | 0.347 | 1.237 | 24.1 | 0.119 |
| Plywood, indoor use (600 kg/m3) | 0.213 | 0.856 | 54.0 | 0.507 |
| Plywood, outdoor use, Okoume plantation (600 kg/m3) | 0.371 | 1.552 | 67.6 | 0.576 |
| paper | | | | |
| Paper, woodfree coated | 0.28 | 1.26 | 55 | 0.27 |
| Board (from recycled paper) | 0.18 | 0.99 | 16 | 0.10 |

For a list of 260 wood species, see www.ecocostsvalue.com tab data.
The characteristics of wood species (e.g. specifik gravity, durability) can be found at http://www.houtinfo.nl/ (Dutch) and
http://www.wood-database.com/wood-articles/database-terms/ (English

# 1.8 Wood, Wood products, and Paper, End of Life

*Table 1.16 Wood, Wood products, and Paper, End of Life*

| Wood, Wood products, and Paper (per kg) | eco-costs | carbon footprint | CED | recipe |
|---|---|---|---|---|
| Idemat 2010 | euro | kg $CO_2$ eq | MJ | Pt |
| combustion of wood in electrical power plant | | | | |
| Hardwood 0% MC, Bamboo, Cork | -0.24 | -1.36 | -29 | -0.12 |
| Hardwood 12% MC, Bamboo, Cork | -0.21 | -1.18 | -25 | -0.10 |
| Hardwood, fresh, 50% MC, Bamboo, Cork | -0.11 | -0.60 | -13 | -0.05 |
| Paper, Board, Leather, (12%MC) | -0.20 | -1.13 | -24 | -0.10 |
| Softwood 0% MC | -0.25 | -1.42 | -31 | -0.12 |
| Softwood 12% MC | -0.22 | -1.23 | -26 | -0.10 |
| Softwood, fresh, 50% MC | -0.11 | -0.62 | -13 | -0.05 |
| municipal waste incineration of wood with electricity | | | | |
| Hardwood 0%MC, Bamboo, Cork | -0.13 | -0.75 | -16 | -0.06 |
| Hardwood 12%MC, Bamboo, Cork | -0.12 | -0.65 | -14 | -0.05 |
| Hardwood, fresh, 50%MC, Bamboo, Cork | -0.06 | -0.33 | -7 | -0.03 |
| Paper, Board, Leather (12%MC) | -0.11 | -0.62 | -13 | -0.05 |
| Softwood, 0%MC | -0.14 | -0.78 | -17 | -0.07 |
| Softwood, 12%MC | -0.12 | -0.68 | -15 | -0.06 |
| Softwood,fresh, 50%MC | -0.06 | -0.35 | -7 | -0.03 |
| landfill | | | | |
| landfill | 0.118 | - | - | - |

## 1.9 Other materials

*Table 1.17 Other materials, production, cradle-to-gate*

| other materials (per kg)<br>Idemat 2010 | eco-costs<br>euro | carbon footprint<br>kg $CO_2$ eq | CED<br>MJ | recipe<br>Pt |
|---|---|---|---|---|
| materials, agricultural | | | | |
| Leather | 0.66 | 2.40 | 54 | 0.23 |
| Rape oil | 0.69 | 1.91 | 64 | 0.45 |
| Jute fibres, India | 0.18 | 0.57 | 21 | 0.13 |
| materials, ceramics | | | | |
| Glaze (in addition to Porcelain and Stoneware) | 1.62 | 0.00 | 0 | 0.00 |
| Porcelain | 0.08 | 0.37 | 7 | 0.04 |
| Stoneware | 0.06 | 0.33 | 6 | 0.03 |
| materials, chemicals | | | | |
| Lime | 0.11 | 0.75 | 4 | 0.05 |
| Silicagel | 0.42 | 1.12 | 19 | 0.14 |
| materials, construction | | | | |
| Cement (CORUS) | 0.04 | 0.24 | 4 | 0.02 |
| Cement (Portland) | 0.11 | 0.72 | 3 | 0.04 |
| Clinker | 0.05 | 0.33 | 6 | 0.03 |
| CORUS slags | 0.00 | 0.00 | 0 | 0.00 |
| Bitumen | 0.81 | 0.43 | 52 | 0.16 |
| Ceramics, brick | 0.04 | 0.24 | 3 | 0.02 |
| Concrete | 0.03 | 0.13 | 1 | 0.01 |
| Concrete (reinforced) | 0.05 | 0.19 | 2 | 0.02 |
| Crushed concrete aggregate | 0.00 | 0.01 | 0 | 0.00 |
| cork slab insulation | 0.24 | 1.16 | 52 | 0.26 |
| glass wool | 0.31 | 1.49 | 49 | 0.16 |
| Rockwool | 0.29 | 1.08 | 20 | 0.14 |
| Gravel | 0.01 | 0.02 | 0 | 0.00 |
| Sand | 0.01 | 0.02 | 0 | 0.00 |
| materials, construction, paint | | | | |
| Acrylic varnish transparent, liqyud, water based | 0.29 | 1.31 | 34 | 0.15 |
| Acrylic varnish white, liqyud, water based | 1.86 | 1.87 | 46 | 0.21 |
| Alkyd paint transparent, liquid, solvent based | 0.50 | 2.12 | 81 | 0.35 |
| Alkyd paint transparent, liquid, water based | 0.40 | 1.94 | 44 | 0.23 |
| Alkyd paint white, liquid, solvent based | 2.86 | 2.86 | 83 | 0.39 |
| Alkyd paint white, liquid, water based | 2.79 | 2.74 | 58 | 0.31 |
| Alkyd paint, solvent based, emissions during painting | 0.98 | 0.00 | 0 | 0.00 |
| materials, fibres | | | | |
| Aramid st gr | 10.16 | 14.08 | 1693 | 1.23 |

| | | | | |
|---|---|---|---|---|
| Carbon fibre | 2.94 | 12.55 | 339 | 1.55 |
| Glass fibre | 0.11 | 0.48 | 9 | 0.05 |
| materials, fuels (€/kg) | | | | |
| Diesel low-sulphur (excluding combustion) | 0.83 | 0.52 | 55 | 0.17 |
| Diesel low-sulfur including combustion | 1.26 | 3.72 | 55 | 0.32 |
| Petrol (excluding combustion) | 0.87 | 0.71 | 57 | 0.02 |
| Petrol including combustion | 1.31 | 3.90 | 57 | 0.11 |
| materials, glass (€/kg) | | | | |
| Glass, uncoated for windows etc. | 0.21 | 0.98 | 13 | 0.09 |
| Glass for bottles | 0.21 | 0.888 | 17 | 0.00 |
| Glass from recycled bottles (estimate) | 0.07 | 0.373 | 8 | 0.00 |
| materials, laminates (€/kg) | | | | |
| Glare 1-3/2-0.3 | 3.79 | 12.74 | 229 | 1.19 |
| Glare 3-3/2-0.2 | 2.79 | 9.45 | 183 | 0.92 |
| Glare 3-6/5-0.4 | 2.66 | 8.50 | 143 | 0.80 |
| Glare 4-6/5-0.4 | 9.51 | 30.37 | 512 | 2.88 |
| Hylite | 4.76 | 12.75 | 265 | 1.11 |
| Glues: take polymers | | | | |

**Note:**

Diesel: 1 kg = 1.20 litre 1 litre = 0.83 kg

Petrol: 1 kg = 1.35 litre 1 litre = 0.74 kg

For an extensive list of chemicals, see www.ecocostsvalue.com tab data.

# 1.10 Electronics

*Table 1.18 Electronic components, production, cradle-to-gate*

| Idemat 2010 and Ecoinvent v2.2 | unit | eco-costs euro | carbon footprint kg $CO_2$ eq | CED MJ | recipe Pt |
|---|---|---|---|---|---|
| Idemat2010 | | | | | |
| AA cell battery (Alkaline) | p | 0.03 | 0.07 | 1 | 0.01 |
| AA cell battery (Li-ion) | p | 0.15 | 0.18 | 3 | 0.02 |
| Electric cord, 1000 W, $3 \times 0.5$ mm$^2$, domestic (per m) | m | 0.075 | 1.04 | 3.6 | 0.024 |
| IC's (area) | m$^2$ | 2547.58 | 14699.38 | 115322 | 998.61 |
| IC's (weigth) | kg | 1683.42 | 9339.81 | 72419 | 632.35 |
| Lead battery cars (39 Wh per kg) | kg | 0.87 | 1.25 | 19 | 0.23 |
| Li-Ion battery laptops | kg | 4.68 | 5.83 | 109 | 1.01 |
| Li-Ion battery scooters and cars (99 Wh per kg) | kg | 3.05 | 8.09 | 324 | 1.28 |
| NiCd battery AA-cell | p | 0.14 | 0.21 | 3 | 0.03 |
| NiCd battery C-cell | p | 0.24 | 0.41 | 5 | 0.05 |
| NiMH battery for laptops | kg | 12.86 | 18.50 | 261 | 2.75 |
| NiMH battery for scooters and cars | kg | 14.78 | 19.59 | 291 | 3.06 |
| Printed board | kg | 123.28 | 251.68 | 4246 | 41.40 |
| solder Lead Tin/Lead 60/40 (normal) | kg | 10.69 | 10.78 | 199 | 2.37 |
| solder leadfree electronic industry (Ag3.9, Cu0.6) | kg | 25.18 | 20.56 | 370 | 5.06 |
| solder Tin/Lead 63/37 solder electronic industry | kg | 11.11 | 11.41 | 213 | 2.47 |
| Ecoinvent: equipment | | | | | |
| CRT screen, 17 inches, at plant/GLO S | p | 122.77 | 252.39 | 4451 | 35.69 |
| Desktop computer, without screen, at plant/GLO S | p | 114.81 | 269.93 | 4670 | 39.94 |
| Keyboard, standard version, at plant/GLO S | p | 11.98 | 25.78 | 436 | 3.70 |
| Laptop computer, at plant/GLO S | p | 76.16 | 209.44 | 2730 | 25.13 |
| LCD flat screen, 17 inches, at plant/GLO S | p | 114.28 | 335.80 | 4924 | 38.48 |
| Mouse device, optical, with cable, at plant/GLO S | p | 2.12 | 5.06 | 88 | 0.77 |
| Ecoinvent: components | | | | | |
| Fan, at plant/GLO S | kg | 3.94 | 11.65 | 247 | 1.61 |
| Backlight, LCD screen, at plant/GLO S | kg | 2.78 | 10.69 | 176 | 1.11 |
| Capacitor, electrolyte type, < 2cm height, at plant/GLO S | kg | 17.36 | 48.97 | 941 | 5.47 |
| Capacitor, electrolyte type, > 2cm height, at plant/GLO S | kg | 11.80 | 46.55 | 906 | 4.56 |
| Capacitor, film, through-hole mounting, at plant/GLO S | kg | 22.01 | 46.95 | 917 | 6.23 |
| Capacitor, Tantalum-, through-hole mounting, at plant/GLO S | kg | 132.85 | 189.09 | 3252 | 23.23 |
| Connector, clamp connection, at plant/GLO S | kg | 4.41 | 8.67 | 164 | 1.54 |
| Inductor, unspecified, at plant/GLO S | kg | 52.14 | 58.81 | 1060 | 12.15 |
| Integrated circuit, IC, logic type, at plant/GLO S | kg | 486.27 | 1011.94 | 16253 | 179.58 |
| Integrated circuit, IC, memory type, at plant/GLO S | kg | 127.59 | 506.20 | 9619 | 56.76 |
| Light emitting diode, LED, at plant/GLO S | kg | 46.54 | 229.32 | 4642 | 22.38 |

| | | | | | |
|---|---|---|---|---|---|
| Power adapter, for laptop, at plant/GLO S | p | 2.70 | 3.77 | 62 | 0.60 |
| Resistor, unspecified, at plant/GLO S | kg | 65.73 | 55.70 | 1011 | 17.62 |
| Transformer, low voltage use, at plant/GLO S | kg | 1.91 | 3.26 | 56 | 0.66 |
| Transistor, unspecified, at plant/GLO S | kg | 43.29 | 144.72 | 2891 | 16.63 |
| Wafer, fabricated, for integrated circuit, at plant/GLO S | $m^2$ | 13023.01 | 71208.73 | 782975 | 5385.51 |
| Printed wiring board, mounted, Desktop PC mainboard, at plant/GLO S | kg | 74.33 | 160.52 | 2780 | 26.25 |
| Printed wiring board, mounted, Laptop PC mainboard, at plant/GLO S | kg | 108.21 | 267.15 | 4631 | 41.11 |
| Printed wiring board, power supply unit desktop PC, solder mix, at plant/GLO S | kg | 12.87 | 40.57 | 768 | 4.65 |
| Printed wiring board, surface mount, at plant/GLO S | $m^2$ | 68.76 | 284.95 | 5341 | 31.89 |
| Printed wiring board, surface mounted, unspec., solder mix, at plant/GLO S | kg | 111.48 | 251.45 | 4242 | 41.33 |

For a extensive list of electronic components see www.ecocostsvalue.com tab data.

# 1.11 Buildings

*Table 1.19 Buildings, cradle-to-site, The Netherlands*

| http://www.winket.nl/root/home---english | unit | eco-costs (€) detached 1 dwelling | eco-costs (€) terraced 10-20 dwellings | eco-costs (€) apartment 10-20 apartments |
|---|---|---|---|---|
| Substructure pile foundation | m² area built on | 82 | 47 | 44 |
| Substructure beams | m² area built on | - | 30 | 64 |
| Primary structure (lime stone, wide-slab floor) | m² external gross floor area | 65 | 78 | 72 |
| Primary structure (concrete cast in situ) | m² external gross floor area | - | - | 112 |
| Roof pitched | m² closed roof | 43 | 26 | - |
| Roof flat | m² closed roof | 30 | 20 | 19 |
| Roof opening | m² roof opening | 378 | 235 | 235 |
| Façade | m² closed façade | 25 | 28 | 23 |
| Façade opening wood (fsc) | m² façade openings | 135 | 147 | 152 |
| Façade opening aluminium | m² façade openings | 64 | 71 | 64 |
| Façade opening synthetic material | m² façade openings | 73 | 80 | 76 |
| Internal structures and finishings | m² external gross floor area | 30 | 21 | 36 |
| Mechanical and electrical services | m² external gross floor area | 25 | 19 | 29 |
| Furnishings, fittings basis | m² external gross floor area | 7 | 5 | 6 |
| Furnishings, fittings extra | m² external gross floor area | 20 | - | - |
| External structures and finishing | m² area not built on | 0 | 9 | 5 |
| Sundries | m² external gross floor area | 2 | 1 | 2 |
| direct construction subtotal | m² external gross floor area | 268 | 243 | 273 |
| building site | m² external gross floor area | 13 | 10 | 12 |
| overheads contractor | m² external gross floor area | 9 | 7 | 8 |
| construction total | m² external gross floor area | 289 | 260 | 293 |

Extensive databases on buildings can be found on the website www.winket.nl
tab reference projects http://www.winket.nl/root/home---english/reference-projects
(look at the specific reference projects).